LAUREL STREET OVERCROSSING

CALTRANS' FIRST MULTI-SPAN PRECAST ACCELERATED BRIDGE CONSTRUCTION PILOT PROJECT

DES-ACEC Quarterly Meeting
January 26, 2018

Dorie Mellon
Structure Policy & Innovation
Division of Engineering Services
California Department of Transportation

ACCELERATED BRIDGE CONSTRUCTION
Caltrans

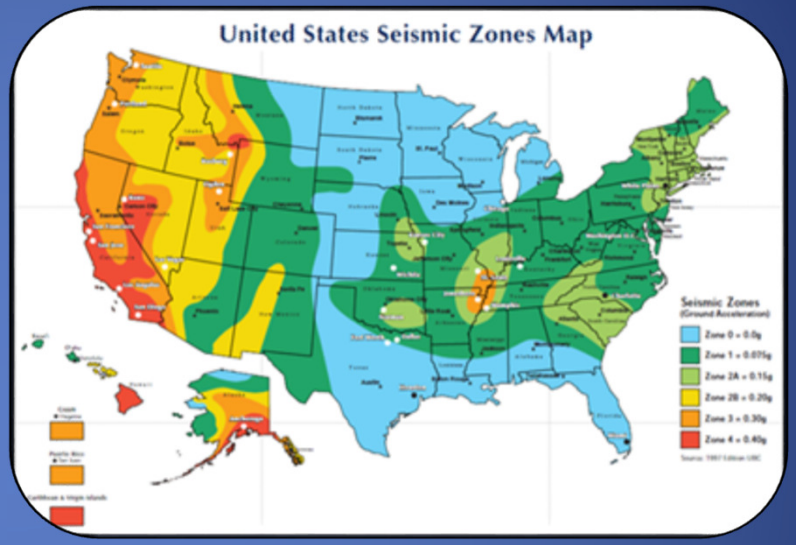
Caltrans ABC Seismic Research

ABC Related Seismic Research at Caltrans

	Arena	Researcher	$$$
1	NGB - Column Connections 65A0372-2176	UNR	$ 307,815
2	CFT 1 - Footing Connections 59A0641-1972	UW	$ 384,503
3	CFT 2 - Bent Cap Connections 65A0446-2417	UW	$ 399,539
4	Column-Pileshaft 65A0466-2423	UNR	$ 279,539
5	PC Bridge Columns w/Energy Jts 59A0591-1999	UNR	$ 300,000
6	Girder Continuity 1 59A0615-2001	ISU	$ 609,000
7	Girder Continuity 2 65A0411-2265	ISU	$ 462,000
8	Column Footing Conn-Pins 65A0423-2281	UNR	$ 187,883
9	Structure Isolation for ABC-OSB TO 1-59A0791	SCSoln	$ 357,000
10	Continuity Analysis TO 3-59A0791	SCSoln	$ 240,000
11	PC Full Depth Deck Panels 59A0519-2544	UNR	$ 264,575
12	ABC System Bridge(s) 65A0589-2757	UNR	$ 770,295
13	Seismic Anchorage Performance 65A0607-3022	UNR	$ 295,689
14	Recovery Column 65A0638-2877	UCSD	$ 509,350
			$ 5,367,188

Ongong Contracts

Upcoming Contracts



1994 Northridge Earthquake

1989 Loma Prieta Earthquake

ACCELERATED BRIDGE CONSTRUCTION

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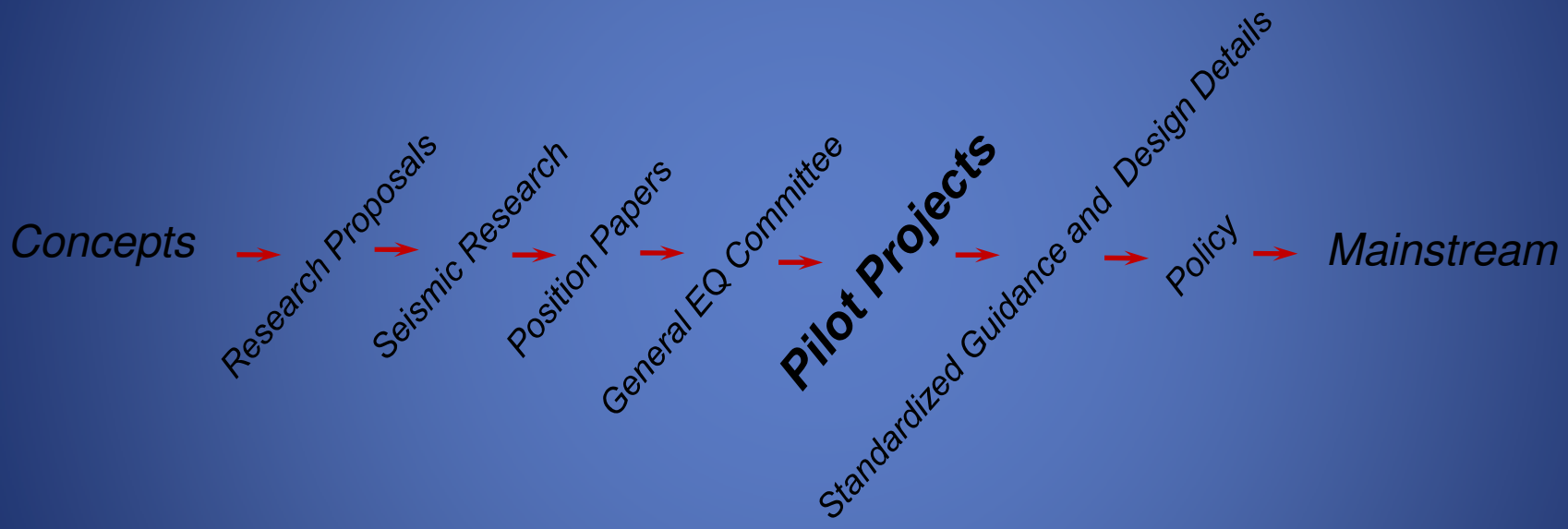
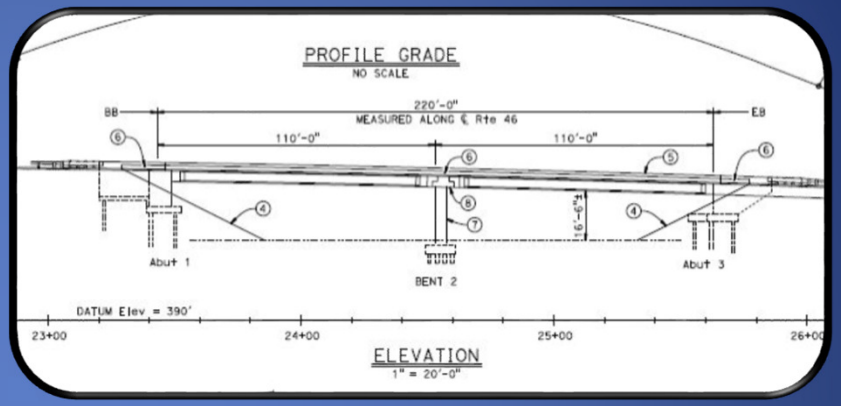
Caltrans Seismic Research Deployment Sequence

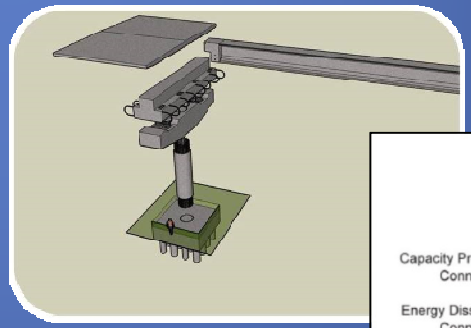


ACCELERATED BRIDGE CONSTRUCTION

ABC Multi-Span Precast Bridge Pilot Program

- Deploy ABC research
- Focus on connections & constructability
- Gather lessons learned to improve efficiency & reduce risk
- Develop standardized guidance, plan details and contract specifications
- Educate project development staff, construction staff and contractors





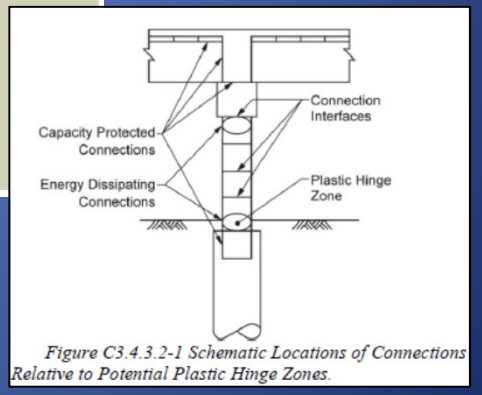
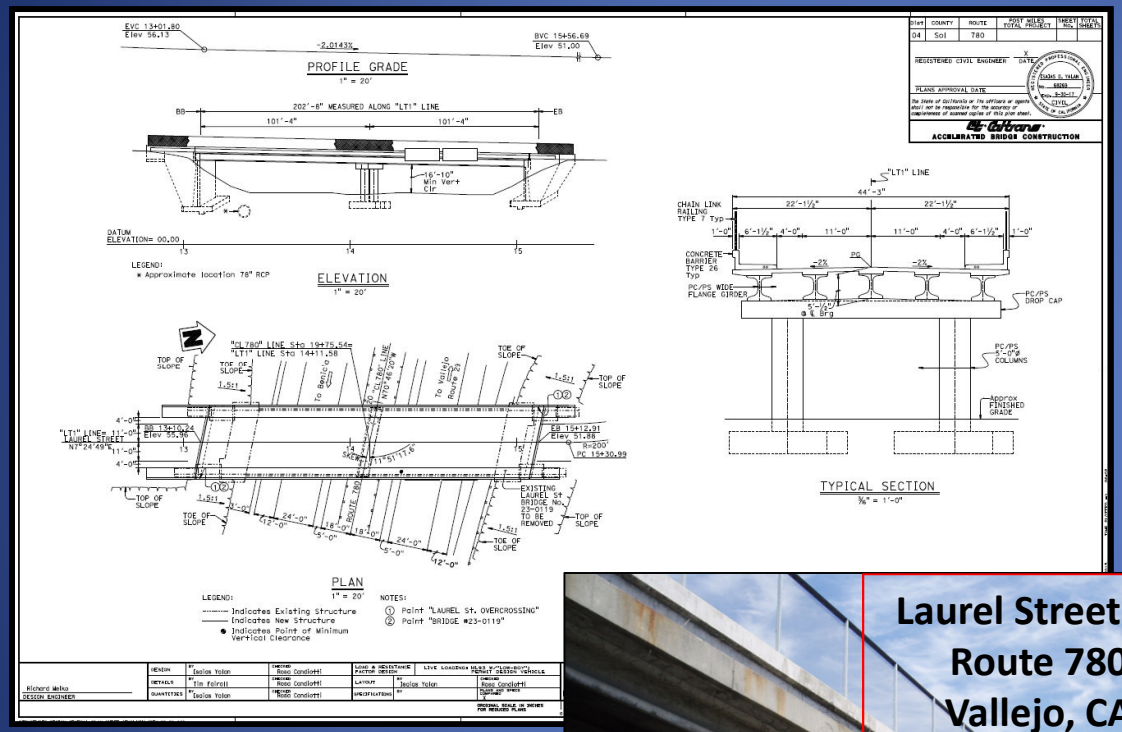


Figure C3.4.3.2-1 Schematic Locations of Connections Relative to Potential Plastic Hinge Zones.

ACCELERATED BRIDGE CONSTRUCTION

Laurel Street OC (Replace)



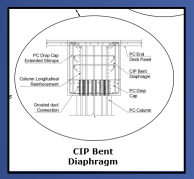
Laurel Street OC
Route 780
Vallejo, CA

Design-Bid-Build
Low Bid Procurement

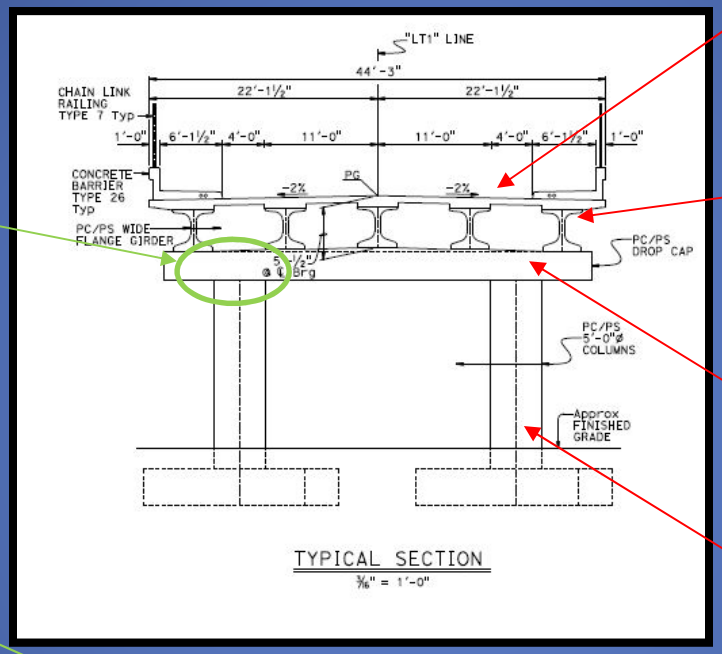
Caltrans ACCELERATED BRIDGE CONSTRUCTION

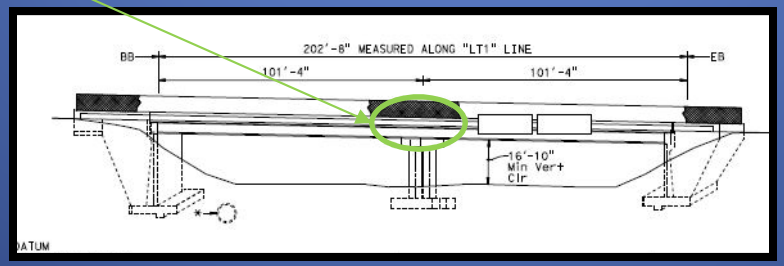
Laurel Street OC (Replace)

Column to Cap Connection
UNR CA14-2176



Girder Continuity Connection
ISU CA16-2265





Rapid Strength Concrete Cast-in-place Deck

Precast Wide Flange Girder

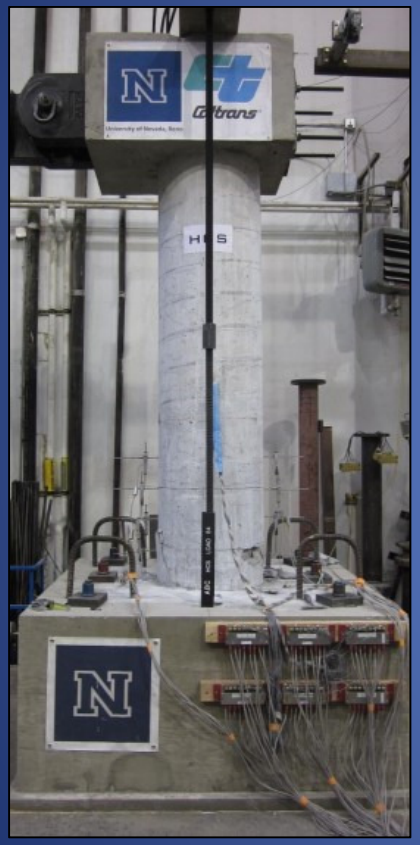
Precast Drop Cap

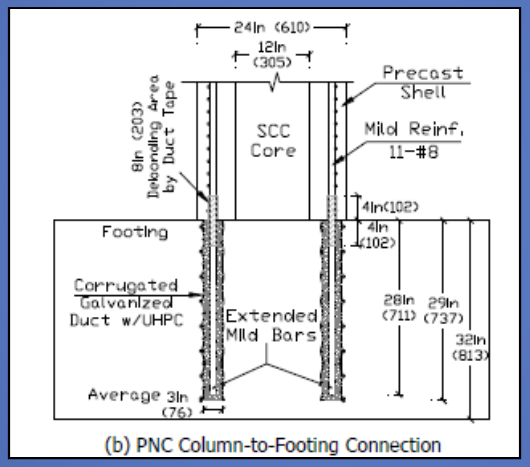
Precast Column

Caltrans ACCELERATED BRIDGE CONSTRUCTION

Next Generation of Bridge Columns for ABC in High Seismic Zones

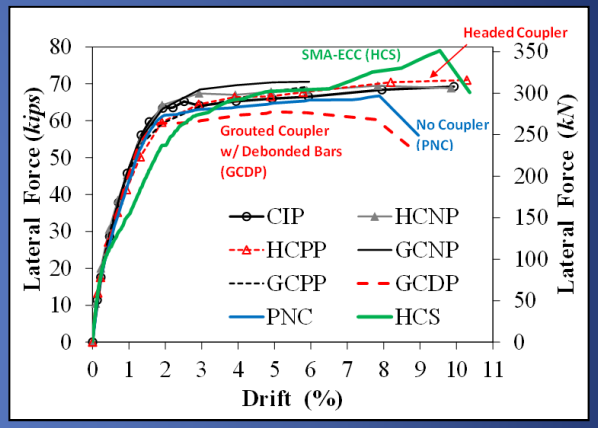
M. Tazarv, M. Saiid Saiidi
UNR CA14-2176





(b) PNC Column-to-Footing Connection

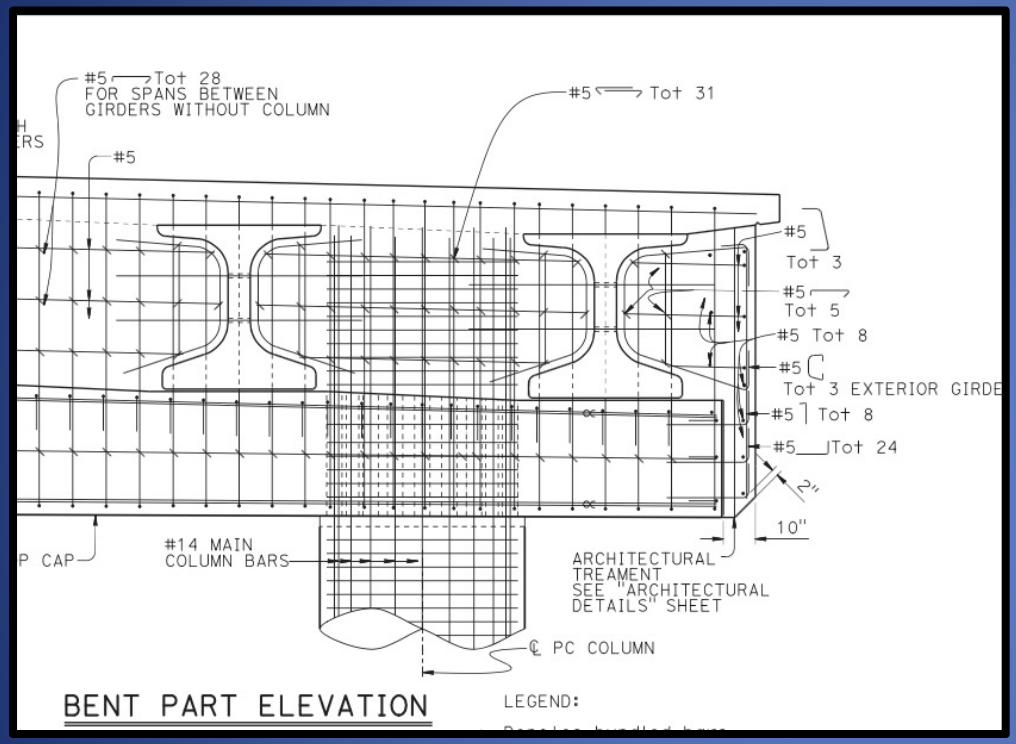
UHPC Filled Duct Connections (PNC)

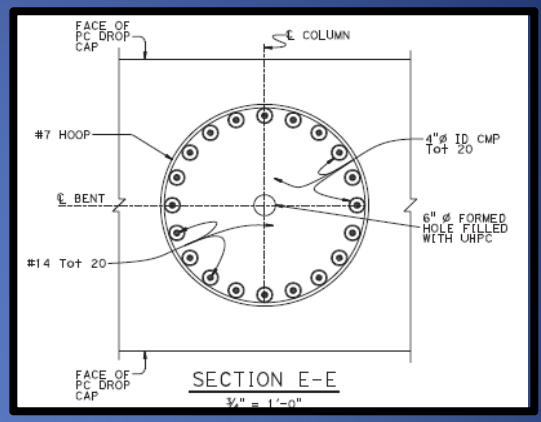


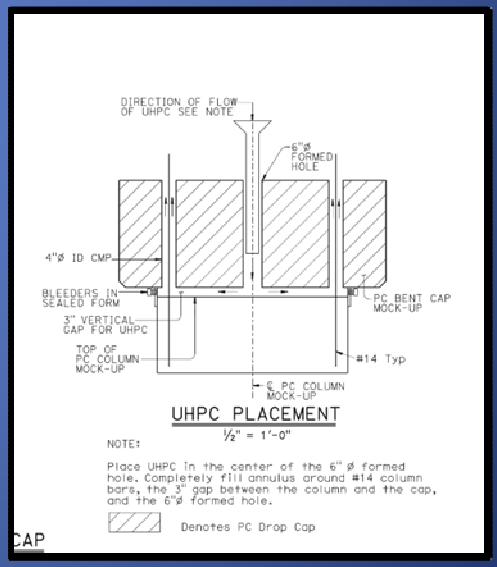
ACCELERATED BRIDGE CONSTRUCTION

Connection Design

Column to Cap







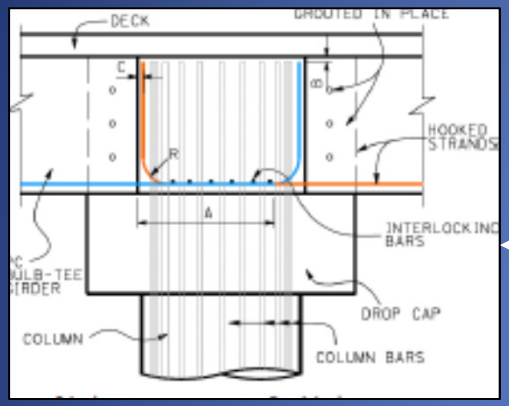
20 #14 bars thread through 4” ID
UHPC filled ducts

UHPC Placement

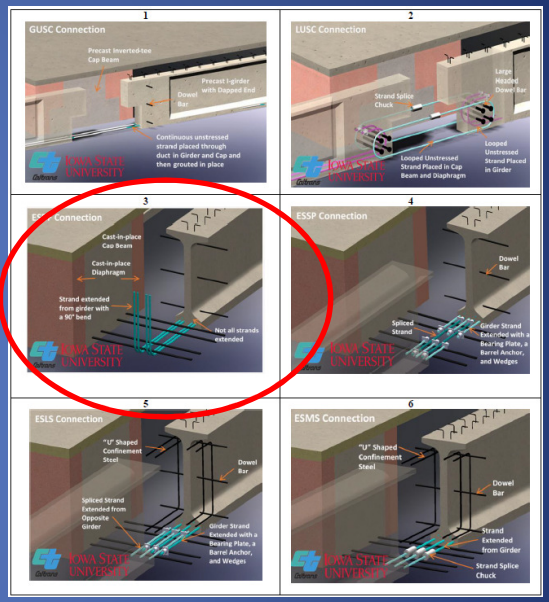
ACCELERATED BRIDGE CONSTRUCTION
Caltrans

Seismic Performance of Precast Girder-to-Cap for ABC of Integral Bents

J. Vander Werff, R. Peggar, Z.Cheng, S. Sritharan
ISU CA16-2265



Extended Unstressed Strand Girder Continuity Connection



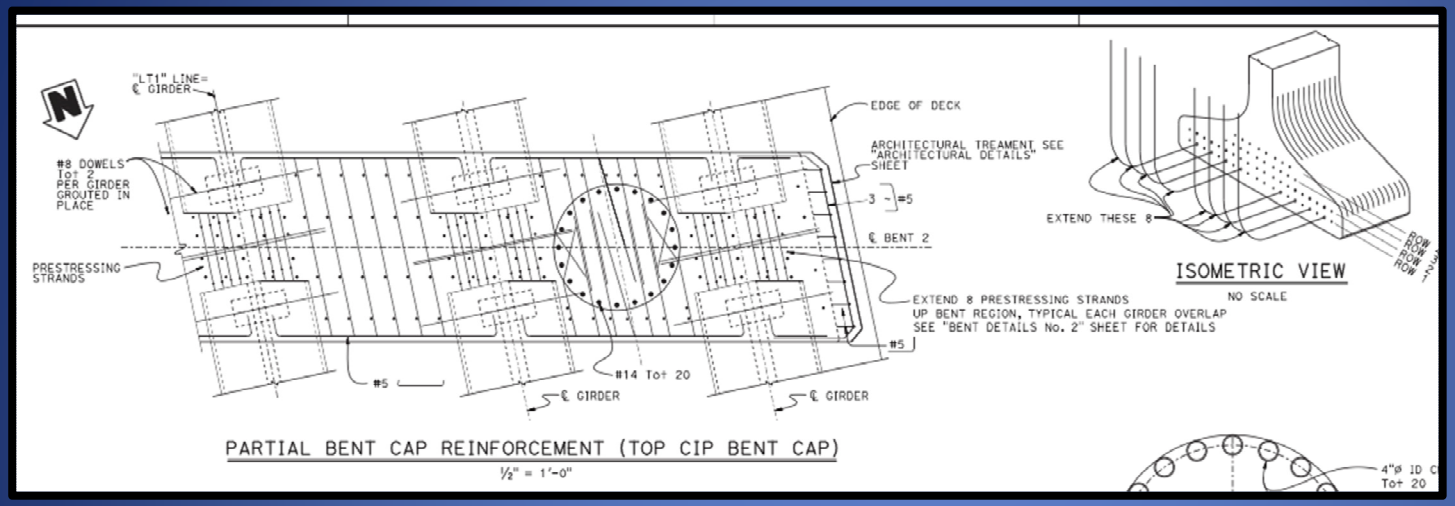
	System	Construction Assembly Risk*	Cost *
Inv-T	1	4	3
	2	2	3
Drop	3	1	1
	4	2	3
	5	3	4
	6	2	4
Mod Drop/CIP	7	2	5

* 1=low, 5=high

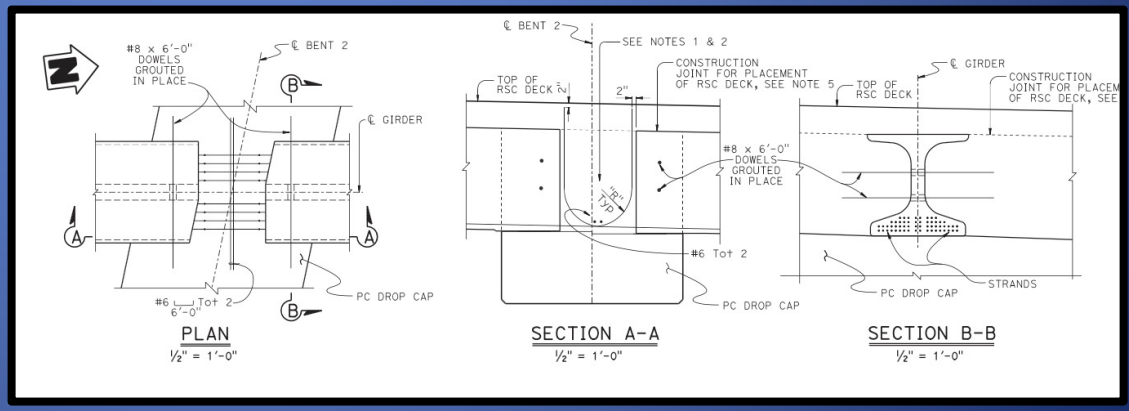
Table 1: Estimated Construction and Cost Risk for Girder Continuity Systems

ACCELERATED BRIDGE CONSTRUCTION

Connection Design
Girder Continuity



Girder Continuity established by 8 overlapping prestressing strands extending out of the precast girders.



ACCELERATED BRIDGE CONSTRUCTION
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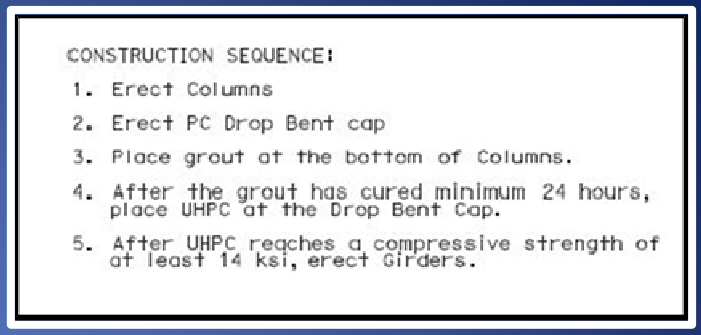
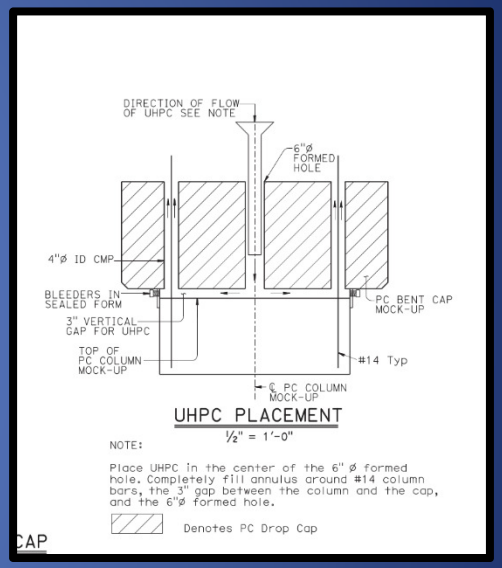
Plans

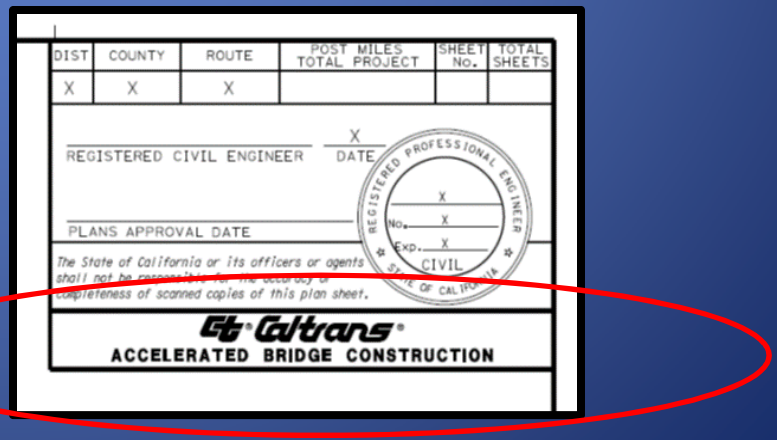
- Construction Sequence
  - Include strength requirements for construction loading
- Concrete Strength & Type Limits
  - Multiple materials used for structural elements and connections
- Fabrication and Erection Tolerances incorporated into design
- UHPC Placement Details
- Mock Up Details
- ABC Logo on Plan Sheets
  - Not business as usual



CONSTRUCTION SEQUENCE:

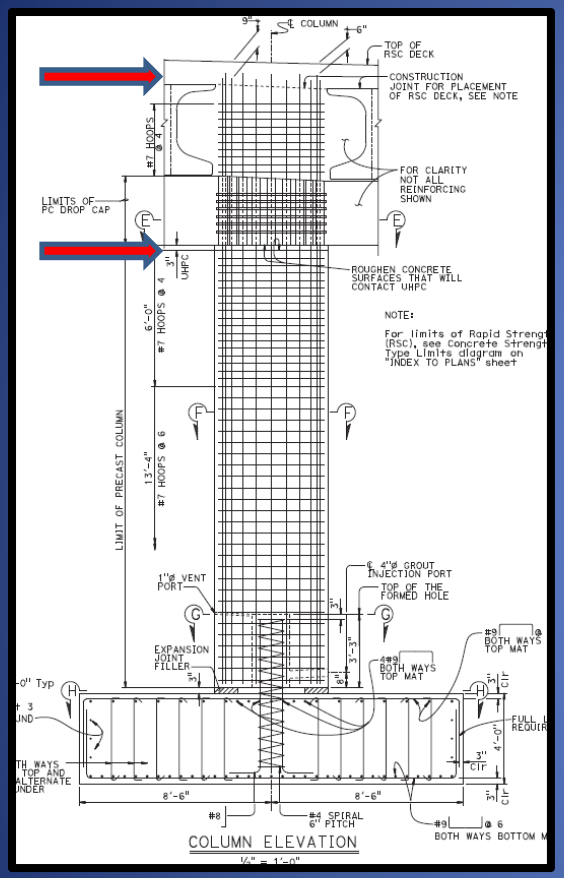
1. Erect Columns
2. Erect PC Drop Bent cap
3. Place grout at the bottom of Columns.
4. After the grout has cured minimum 24 hours, place UHPC at the Drop Bent Cap.
5. After UHPC reaches a compressive strength of at least 14 ksi, erect Girders.



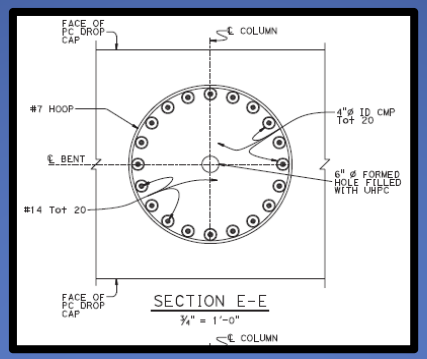


ACCELERATED BRIDGE CONSTRUCTION

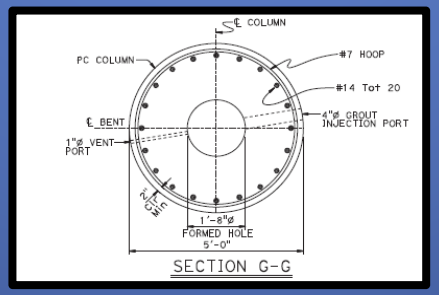
Fabrication & Erection Tolerances Built into the Plans



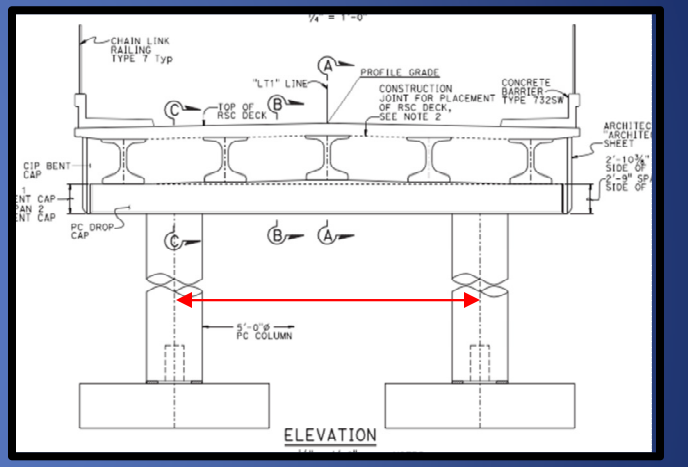
Vertical tolerance in CIP locations



#14 bars (1.88” deformed diameter) in 4” ID ducts



1’ 8” formed hole for 12” shear key



Location, spacing and orientation of columns critical

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Specifications

- No change to design of precast elements and UHPC
- Work plans
- Preconstruction meetings
- Mock Ups
  - RSC Slab
  - UHPC Pull Out
  - UHPC Placement
- Concurrent shop drawing submittal
- Extra time for shop drawing review
- Templates
- Preassembly of columns and bent
- Sole source procurement of UHPC

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UHPC Implementation

- Ductal JS1000 – Lafarge
  - 14 ksi @ 4 days
  - 21 ksi @ 28 days
- Close coordination with FHWA and Lafarge during design and specification development
- Prequalification
- Work plan
- Full Scale Mock Ups
  - UHPC Placement
  - #14 rebar pull out test

ACCELERATED BRIDGE CONSTRUCTION
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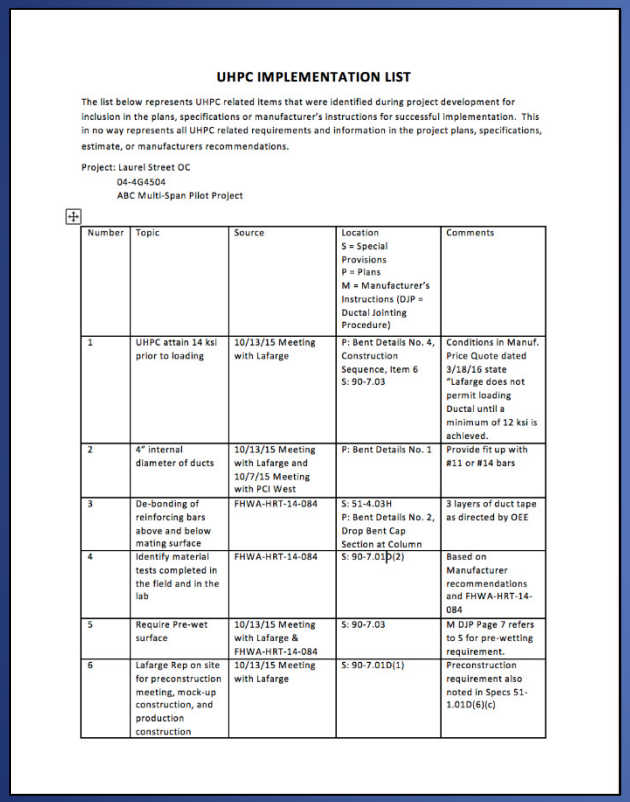
ABC Guidance

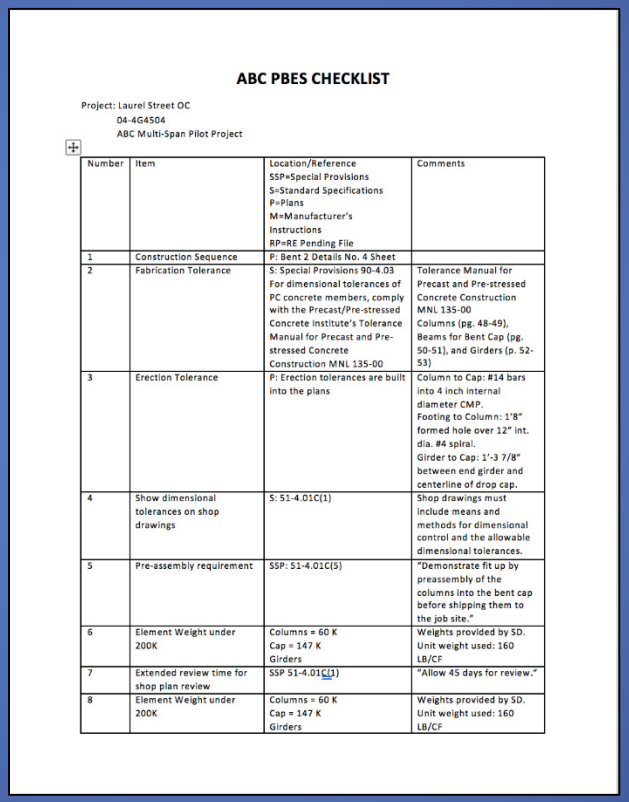


UHPC IMPLEMENTATION LIST

The list below represents UHPC related items that were identified during project development for inclusion in the plans, specifications or manufacturer's instructions for successful implementation. This in no way represents all UHPC related requirements and information in the project plans, specifications, estimate, or manufacturers recommendations.

Project: Laurel Street OC
04-4G4504
ABC Multi-Span Pilot Project

Number	Topic	Source	Location S = Special Provisions P = Plans M = Manufacturer's Instructions (DJP = Ductal Jointing Procedure)	Comments
1	UHPC attain 14 ksi prior to loading	10/13/15 Meeting with Lafarge	P: Bent Details No. 4, Construction Sequence, Item 6 S: 90-7.03	Conditions in Manuf. Price Quote dated 3/18/16 state "Lafarge does not permit loading Ductal until a minimum of 12 ksi is achieved.
2	4" internal diameter of ducts	10/13/15 Meeting with Lafarge and 10/7/15 Meeting with PCI West	P: Bent Details No. 1	Provide fit up with #11 or #14 bars
3	De-bonding of reinforcing bars above and below mating surface	FHWA-HRT-14-084	S: 51-4.03H P: Bent Details No. 2, Drop Bent Cap Section at Column	3 layers of duct tape as directed by OEE
4	Identify material tests completed in the field and in the lab	FHWA-HRT-14-084	S: 90-7.01D(2)	Based on Manufacturer recommendations and FHWA-HRT-14-084
5	Require Pre-wet surface	10/13/15 Meeting with Lafarge & FHWA-HRT-14-084	S: 90-7.03	M DJP Page 7 refers to S for pre-wetting requirement.
6	Lafarge Rep on site for preconstruction meeting, mock-up construction, and production construction	10/13/15 Meeting with Lafarge	S: 90-7.01D(1)	Preconstruction requirement also noted in Specs 51-1.01D(6)(c)



ABC PBES CHECKLIST

Project: Laurel Street OC
04-4G4504
ABC Multi-Span Pilot Project

Number	Item	Location/Reference SSP=Special Provisions S=Standard Specifications P=Plans M=Manufacturer's Instructions RP=RE Pending File	Comments
1	Construction Sequence	P: Bent 2 Details No. 4 Sheet	
2	Fabrication Tolerance	S: Special Provisions 90-4.03 For dimensional tolerances of PC concrete members, comply with the Precast/Pre-stressed Concrete Institute's Tolerance Manual for Precast and Pre-stressed Concrete Construction MNL 135-00	Tolerance Manual for Precast and Pre-stressed Concrete Construction MNL 135-00 Columns (pg. 48-49), Beams for Bent Cap (pg. 50-51), and Girders (p. 52-53)
3	Erection Tolerance	P: Erection tolerances are built into the plans	Column to Cap: #14 bars into 4 inch internal diameter CMP. Footing to Column: 1'8" formed hole over 12" int. dia. #4 spiral. Girder to Cap: 1'-3 7/8" between end girder and centerline of drop cap.
4	Show dimensional tolerances on shop drawings	S: 51-4.01C(1)	Shop drawings must include means and methods for dimensional control and the allowable dimensional tolerances.
5	Pre-assembly requirement	SSP: 51-4.01C(5)	"Demonstrate fit up by preassembly of the columns into the bent cap before shipping them to the job site."
6	Element Weight under 200K	Columns = 60 K Cap = 147 K Girders	Weights provided by SD. Unit weight used: 160 LB/CF
7	Extended review time for shop plan review	SSP 51-4.01C(1)	"Allow 45 days for review."
8	Element Weight under 200K	Columns = 60 K Cap = 147 K Girders	Weights provided by SD. Unit weight used: 160 LB/CF

For example:

- Design Guidance
- Standard Details
- Special Provisions
- Checklists
- Design Examples

Caltrans ACCELERATED BRIDGE CONSTRUCTION

Pull Out Test Mock Up

1. Verify the pull-out strength of the #14 reinforcing bar placed in 4” ID duct filled with 14 ksi UHPC
   - Test to 54 kips to represent eccentric loading of cap during the placement of the girders on one side only.
2. Provide data on the performance of the material in this application
   - Determine the ultimate capacity and failure mechanism of the bar/UHPC system.
3. No acceptance Criteria

ACCELERATED BRIDGE CONSTRUCTION

Pull Out Test June 6, 2017

The mock-up was tested at the Caltrans Materials Testing Laboratory “Translab” 4 days after UHPC placement.

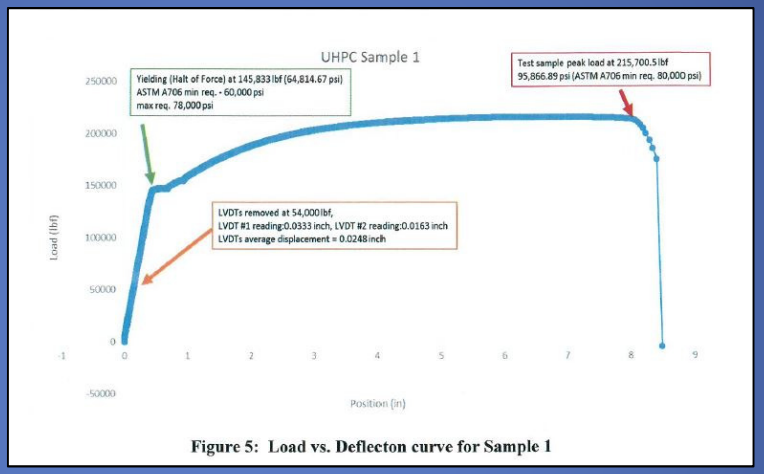
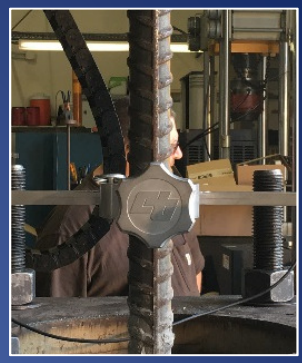


Figure 5: Load vs. Deflecton curve for Sample 1

- Yield at 145 kips
- Peak load at 215 kips
- Rebar achieved ultimate strength
- Rebar remained bonded throughout testing
- No pullout of bar, UHPC, or corrugated duct
- Elongation of bar along debonded length



ACCELERATED BRIDGE CONSTRUCTION
Caltrans

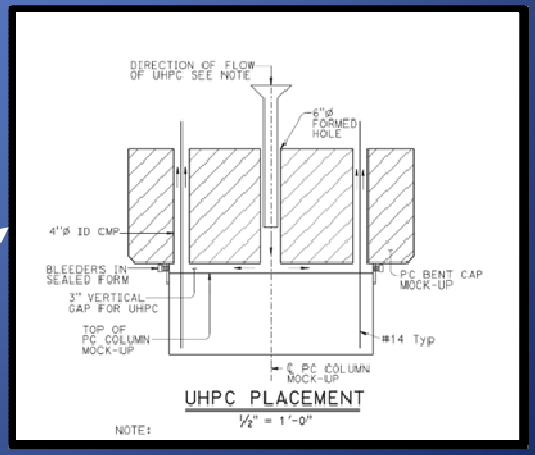
Additional UHPC Tests

- UHPC/PC Interface Bond
- Chlorides and Sulfates Content
- Shrinkage
- Compressive Strength

ACCELERATED BRIDGE CONSTRUCTION
Caltrans

Cap/Column Assembly Mock Up

UHPC was placed as directed on the plans



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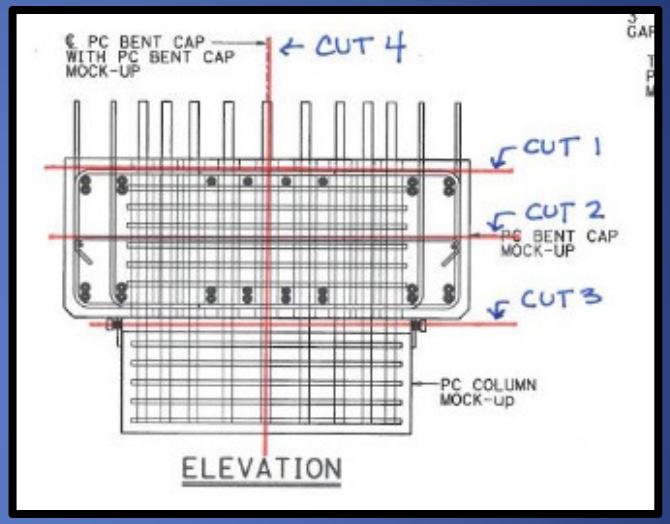
Caltrans

Saw Cut
July 26-28



Specifications called for saw cutting the fit up specimen.

Acceptance criteria stated that mock up must demonstrate that UHPC completely fill spaces and steel fibers are uniformly distributed.

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All spaces filled, uniform distribution of fibers and accurate rebar location.

Cut through bent cap

Cut through 3” UHPC layer between column and cap

ACCELERATED BRIDGE CONSTRUCTION
Caltrans

Precast Elements

Columns (2 EA)

19’ long, 5’ diameter

59,300 lbs.

Cap (1 EA)

43’ long, 7’ wide, 3’ deep

148,500 lbs.

Wide Flange Girders (10 EA)

98’ long, 4’ deep

95,000 lbs.

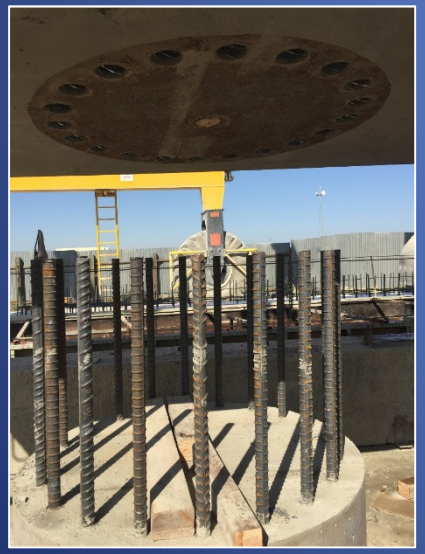
ACCELERATED BRIDGE CONSTRUCTION

Caltrans

Preassembly of cap and columns at the Precast Yard

Preassembly required of full size columns proved problematic

CT allowed contractor to use short columns and template compatibility



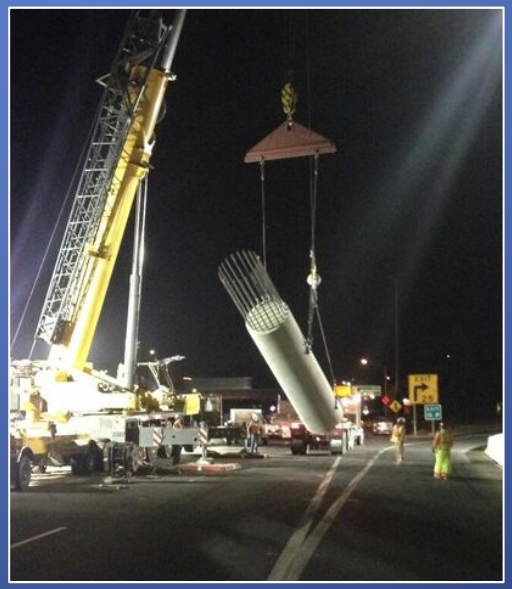
"Bullet" used to guide rebar into ducts

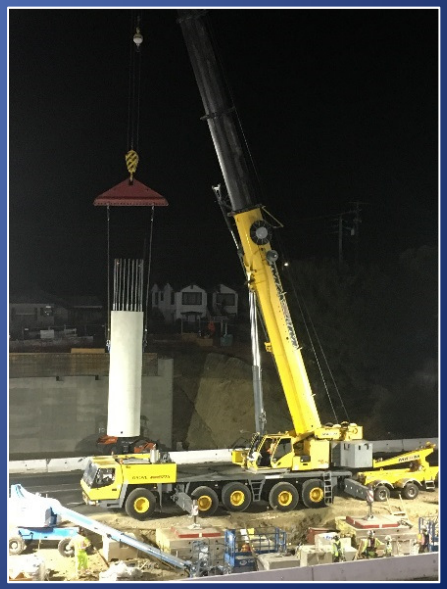
ACCELERATED BRIDGE CONSTRUCTION

Column and Cap Erection August 30, 2017

6 hour closure of Route 780

Columns and Cap erected between 1 AM-4 AM





ACCELERATED BRIDGE CONSTRUCTION

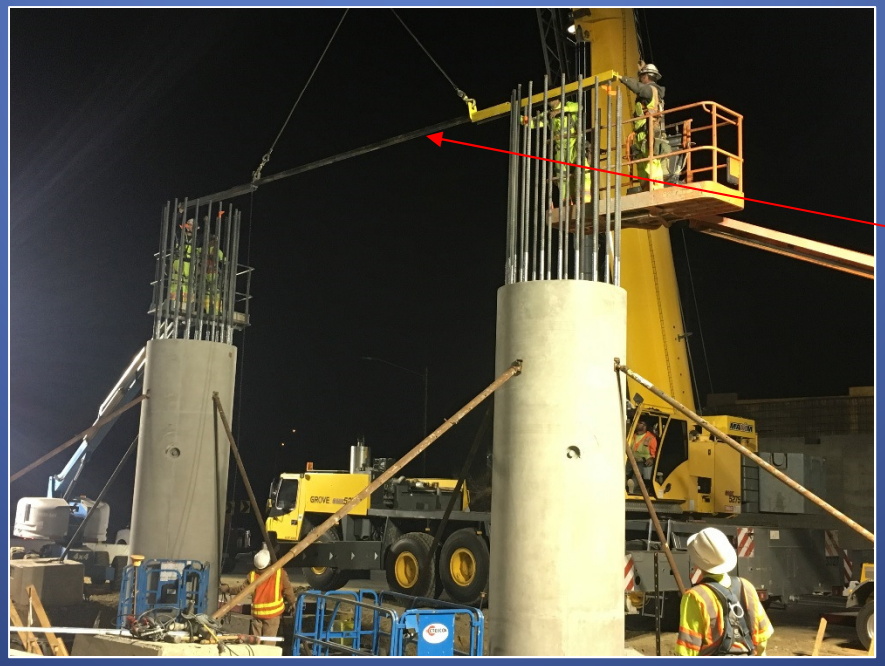
Caltrans

Columns

Line up column for correct rebar orientation above

ACCELERATED BRIDGE CONSTRUCTION

Columns



Column placement template

ACCELERATED BRIDGE CONSTRUCTION

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Metal shims were used to set bent cap grade and provide 3” gap for UHPC placement between column and cap.

ACCELERATED BRIDGE CONSTRUCTION

Caltrans

Bent Cap

ACCELERATED BRIDGE CONSTRUCTION

Grouting of Column Pins and Placement of UHPC in Drop Cap


Non-shrink grout used at base of column

24 cubic feet of UHPC placed in column to cap connection voids

Caltrans ACCELERATED BRIDGE CONSTRUCTION

Girders erected under 2 consecutive full night closure of Route 780

September
13 & 14

ACCELERATED
BRIDGE
CONSTRUCTION
Caltrans

Rapid Strength Concrete Deck

RSC batched in volumetric mixer on site.
f'ci = 3250 psi at 4 hours
f'c = 5,000 psi at 28 days
Max shrinkage: 0.024%

Caltrans ACCELERATED BRIDGE CONSTRUCTION

Contract Acceptance Scheduled for March 2018

ACCELERATED BRIDGE CONSTRUCTION

Lessons Learned

- Pre-bid meeting with contractors
- Increase resourcing for materials QC/QA
- Cylinder prep for UHPC tests new to CA labs
- Modifications to UHPC specifications
- Modifications to preassembly specification
- Additional survey support for placement of columns
- Staging area for RSC material and batching on site
- Pour sequence for deck concrete (bent cap diaphragm last)

Best Practices

- Close communication
  - External: FHWA, UHPC Vendor, Precast Industry, Prime Contractor, Academia
  - Internal: Design, Construction, Materials Engineering, ABC & Seismic Specialists
- Work Plans
- Mock Ups
- UHPC and Precast design and specification check lists
- Provide lead time in contract for paperwork, testing, and procurement
- Documentation of project

Caltrans ACCELERATED BRIDGE CONSTRUCTION

Structure Design: Isaias Yalan, Caltrans
ABC Pilot Coordination: Dorie Mellon, Caltrans
Seismic Connection Design Support: Ron Bromenschenkel, Caltrans
Structure Construction Management: Joe De La Torre, Caltrans
Materials Engineering and Inspection: Justin Palmaymesa, Caltrans
Prime Contractor: RNR Construction Inc
Precast Subcontractor: Con-Fab California LLC
UHPC Supplier: LafargeHolcim
RSC Supplier: Precision Concrete Materials LLC